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Enriching Student's Online Homework Experience in Pre-Calculus Courses: Hints and Cognitive Supports

Nathan Wakefield

University of Nebraska-Lincoln, nathan.wakefield@unl.edu

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Abstract for DBER Group Discussion on 2016-03-03

Authors and Affiliations:

Nathan Wakefield
Director of First Year Mathematics Programs
Department of Mathematics
University of Nebraska-Lincoln

Title

Enriching Student's Online Homework Experience in Pre-Calculus Courses: Hints and Cognitive Supports

Abstract

As part of reforming our Pre-Calculus courses we realized that reforms to instruction needed to be accompanied by reforms to the homework. Homework is completed online using an open-source homework system. In this study we investigated and implemented a new means of providing our students more support on missed questions. Utilizing a new WebWork "hints" feature and leveraging our network of experienced high-school teachers we developed leading questions and helps to prompt student thinking over procedures. Preliminary data shows many students are using these hints and the hints are working as intended. In this presentation I will discuss the development process, refinement process, preliminary data, and ideas for future development.



ENRICHING STUDENT'S ONLINE HOMEWORK EXPERIENCE IN PRE- CALCULUS COURSES: HINTS AND COGNITIVE SUPPORTS

Nathan Wakefield

Joint work with Wendy Smith

This work is supported in part by a grant from the Mabel Elizabeth
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teaching at the University of Nebraska-Lincoln



BACKGROUND

The Department of Mathematics at the University of Nebraska-Lincoln (UNL) in the midst of reforming high-enrollment (first-year) mathematics courses. The reforms include:

Active Learning

Common Activities

Common Lesson Plans

Common Exams & Grading

Common Online Homework (WeBWorK)

Fall Success Rates										
	2007	2008	2009	2010	2011	07-11 Ave.	2012	2013	2014	2015
101	63%	61%	60%	68%	60%	62.4%	59%	80%	80%	80%
103	66%	65%	68%	65%	70%	66.8%		77%	78%	80%



ACTIVE LEARNING

Teaching methods and classroom norms engage students in sense-making activities. Students develop habits of mind of mathematical thinkers: solve problems, conjecture, experiment, explore, create, communicate reasoning. But what happens when student leave the classroom?

How can we better support students when they engage with the online homework?



ACTIVE LEARNING



CLOSE COORDINATION

- Student Course Packet
(168 pages)
- Instructor Course Packet
(270 pages)

University of Nebraska-Lincoln

Course Packet

Math 101
College Algebra

These materials were developed by the UNL Department of Mathematics

2015-2016



EXAMPLE

Worksheet 1.1: Functions and Function Notation

Math 101 2015-16

Problem 6. A person's blood sugar level at a particular time of the day is partially determined by the time of the most recent meal. After a meal, blood sugar level increases rapidly, then slowly comes back down to a normal level. Sketch a person's blood sugar level as a function of the time over the course of a day. Label the axes to indicate normal blood sugar level and the time of each meal.

Problem 7. Which capital letters of the alphabet could be graphs of functions?

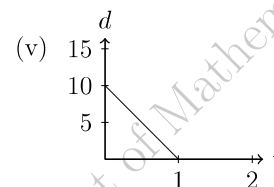
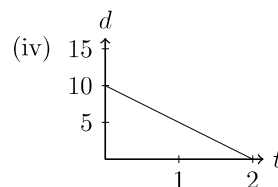
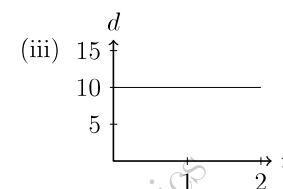
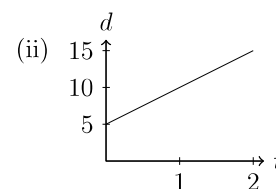
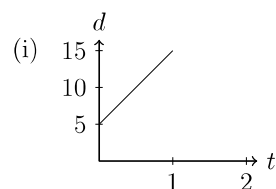


EXAMPLE

Worksheet 1.1: Functions and Function Notation

Math 101 2015-16

Problem 10. *Individual study.* Match each story about a bike ride to one of the graphs below, where d represents distance from home in miles and t is time in hours since the start of the ride. (A graph may be used more than once.)



- (a) Starts 5 miles from home and rides 5 miles per hour away from home.
- (b) Starts 5 miles from home and rides 10 miles per hour away from home.
- (c) Starts 10 miles from home and arrives home one hour later.
- (d) Starts 10 miles from home and is halfway home after one hour.
- (e) Starts 5 miles from home and is 10 miles from home after one hour.



IN THE CLASSROOM

- In the classroom students are engaged in thought provoking activities.
- Instructors work with students to think analytically by responding to students with probing questions pushing students to develop the meta-cognitive skills they need to succeed mathematically.
- However, students do not develop this meta-cognitive skill overnight and homework can be a challenging aspect of the course.



MOTIVATION

- During focus group interviews of students in fall 2014, the biggest complaint students had was the way the online homework system works.
- As the department looks to expand the courses utilizing WeBWork, we wanted to have a focused research project to study our efforts to improve the WeBWork experience for students.



MOTIVATION

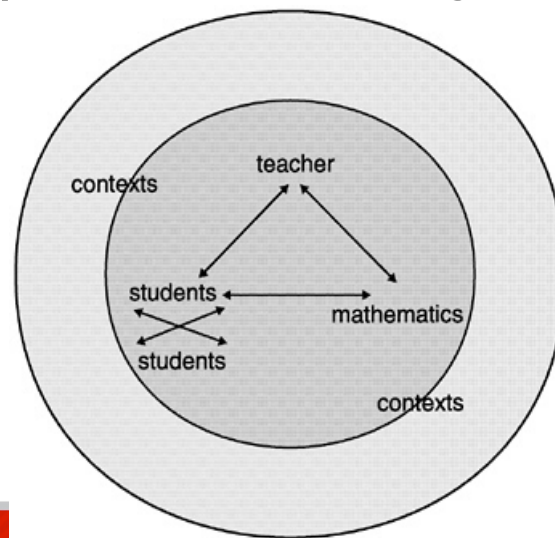
Hauk and Segalla (2005): as a facilitator for engaging in mathematical self-regulation WeBWork is involved only as a monitor for correctness...the web based tool does some monitoring but the responsibility for metacognitive control (response to the monitoring), problem-solving heuristics, and the impact of mathematical beliefs rests on the student. (p. 241)



FRAMEWORK

WeBWork lacks in a key aspect of the triadic reciprocity proposed by Bandura (1986)

WeBWork lacks the environmental interaction with a subject expert to provide the cognitive apprenticeship .



INNOVATION

Can we do a better job of supporting students when they are not with their professor?

Hauk and Segalla (2005) quote students as having reported “I prefer getting feedback from the professor because he could help me understand what I did wrong” (p. 244).



HYPOTHESIS

Using a “Hint” button will provide students with focused questions to prompt higher-order thinking about problems the student had answered incorrectly.

(1 point) `local/setChapter2/Chapter2Section2S1.pg`

Let $f(x) = \frac{x-1}{x+5}$ and let $g(x) = \frac{1}{x(x+5)}$. For what value(s), if any, are the functions undefined? If there are multiple values, enter each value separated by a comma.

The function $f(x)$ is undefined when $x =$.

The function $g(x)$ is undefined when $x =$.

[Hint:](#)

Hint

To find where a function is undefined, consider possible inputs for the function that have undefined outputs. Remember, dividing by 0 is undefined.



METHODS

Instead of providing students with “cookie cutter” examples that increase the likelihood students will try to learn through memorizing procedures rather than reinforcing our active learning philosophy, our hints are in the form of small reminders designed to help students think about common errors related to each particular problem.



METHODS

- The hints were written by experienced high school teachers and graduate students.
- We studied the performance of the N1=488 students in Fall 2015 and the performance of the N2=566 student in Fall 2014.
- A faculty task force provided oversight to ensure standards remained uniform.



EXAMPLES

Use the following formulas for these functions to find and simplify the composite functions.

$$f(x) = 6x^2$$

$$g(x) = 5x - 4$$

$$h(x) = \sqrt{x}$$

$$f(h(x)) = \text{[input box]}$$

$$f(g(x)) = \text{[input box]}$$

$$g(f(h(x))) = \text{[input box]}$$

Hint

Remember in a composition of functions, that the second function becomes the input for the variable in the first function. Start with a set of parentheses representing the input:

$f(x) = 6(\text{new function})^2$, then substitute the expression from the other function and simplify.



RESULTS

- Qualitative results were encouraging, the hints fit our framework.
- Quantitative results were mixed, the hints helped in some ways, but did not help (did no harm) in other ways.



RESULTS: STUDENT INTERVIEWS

We interviewed students near the end of the semester to ask about their uses of hints.

Students recognized these hints were different than “typical” hints.

“In webassign it was almost like a PowerPoint slide show like it will be someone typing on a computer and kind of running you through the work. It will do different numbers from your problem obviously but it teaches you how to do it so that you can turn around and do it for yours.”

Students appreciated the hints most of the time; in crafting hints for what we judged to be the most common student misconceptions, we recognized these hints would not help all students all the time.

“I liked the hints. I feel like they are very helpful and I wish that all of the problems had hints.”

“The hints were kind of hit or miss for me. Sometimes they were really helpful and sometimes they didn’t help what so ever. It just depends on the problem I guess.”

When asked **how we could improve the hints**, the most common answer was: “More hints”

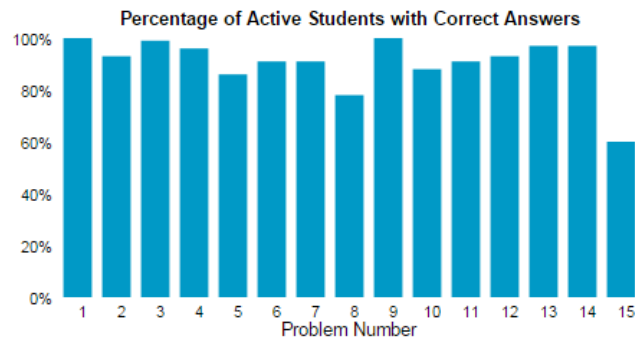
“I guess just having additional steps to it. Like if maybe the first hint wasn’t enough and you continue to get the problem wrong there can be an additional hint, not just the same hint.”



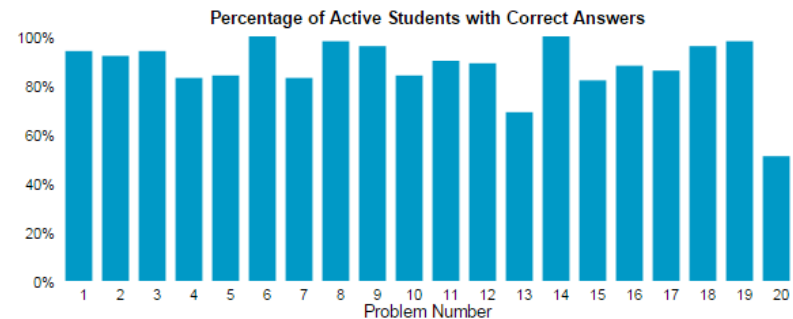
UNFORTUNATELY, THE HINTS DID NOT SEEM TO MAKE A BIG DIFFERENCE FOR LATER PROBLEMS IN THE SAME ASSIGNMENT.

- Spring 2015 N=392

Statistics for 181-Spring-2015 set HW_1_-_Sections_1.1-1.2.
CST



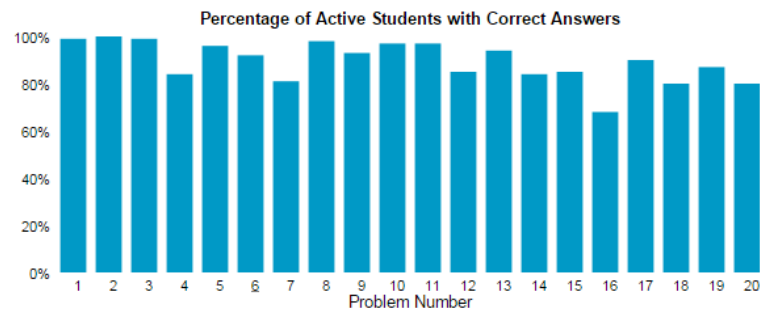
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01/19/2016 at 08:00am CST



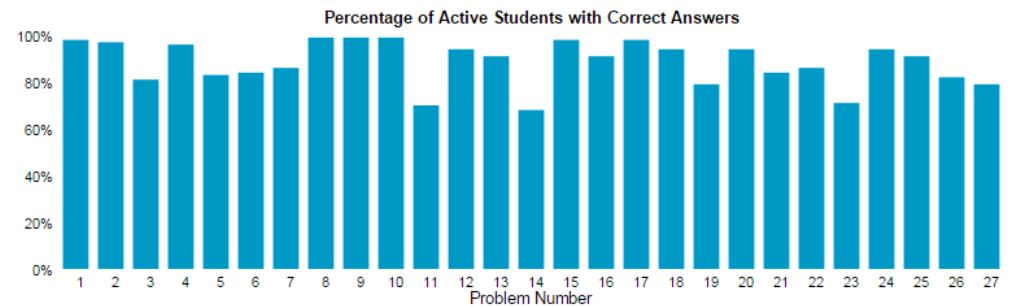
UNFORTUNATELY, THE HINTS DID NOT SEEM TO MAKE A BIG DIFFERENCE FOR LATER PROBLEMS IN THE SAME ASSIGNMENT.

- Spring 2015 N=392
- Spring 2016 N=456

Statistics for 101 set HW_2_-_Sections_1.3-1.4. CST

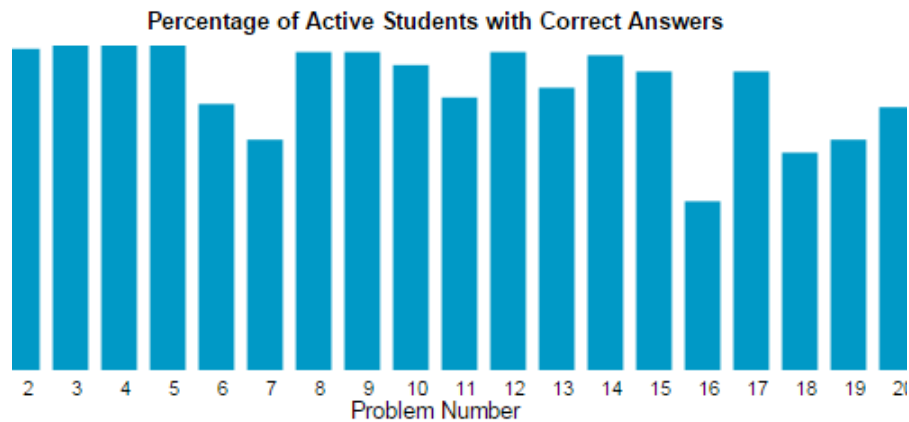


Statistics for 101-Spring-2016 set HW_2_-_Sections_1.3-1.4. 01/26/2016 at 08:00am CST

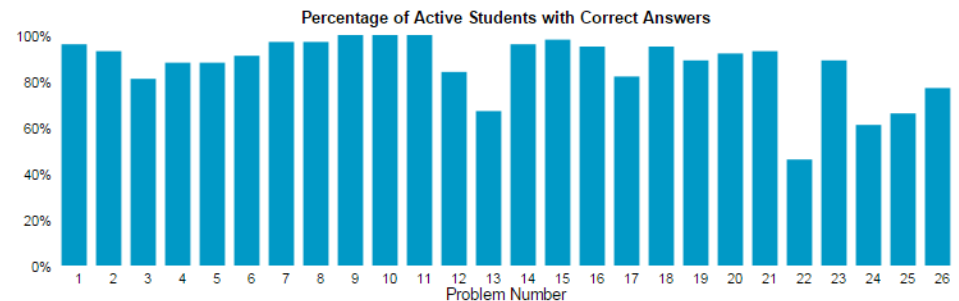


UNFORTUNATELY, THE HINTS DID NOT SEEM TO MAKE A BIG DIFFERENCE FOR LATER PROBLEMS IN THE SAME ASSIGNMENT.

- Spring 2015 N=392
- Statistics for 101 set HW_3 - Sections_1.5-2.1
- Spring 2016 N=456



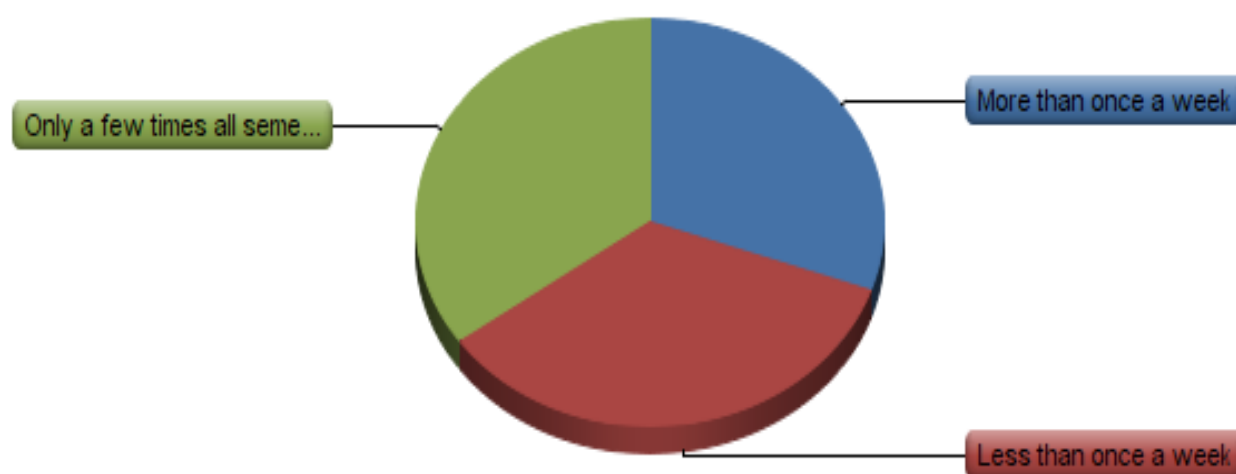
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RESULTS: STUDENT SURVEY

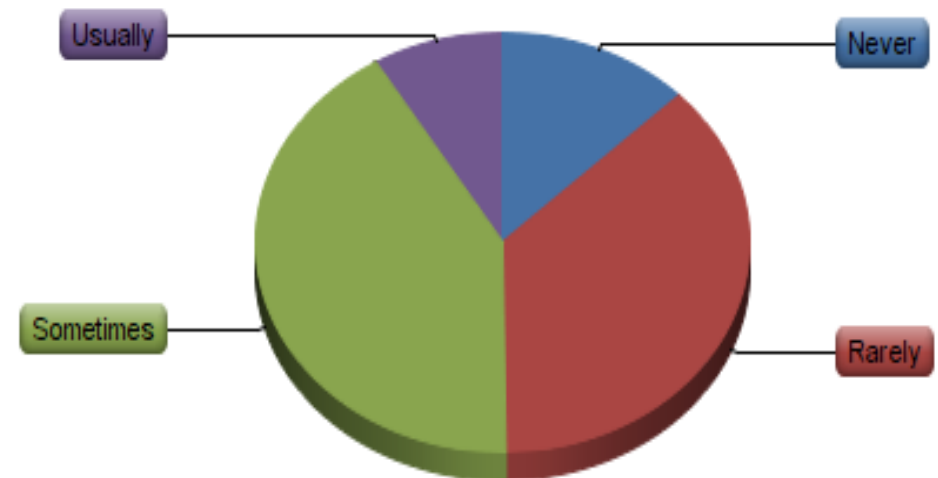
In November 2015, we invited the $N=566$ precalculus students to response to a brief survey about their use of hints. 297 students responded, of which 84% say they've used the hints at least once.

*How often do you
access WeBWork
hints?*



RESULTS: STUDENT SURVEY

*Hints _____
give enough
information for me to
get started on the
problem.*



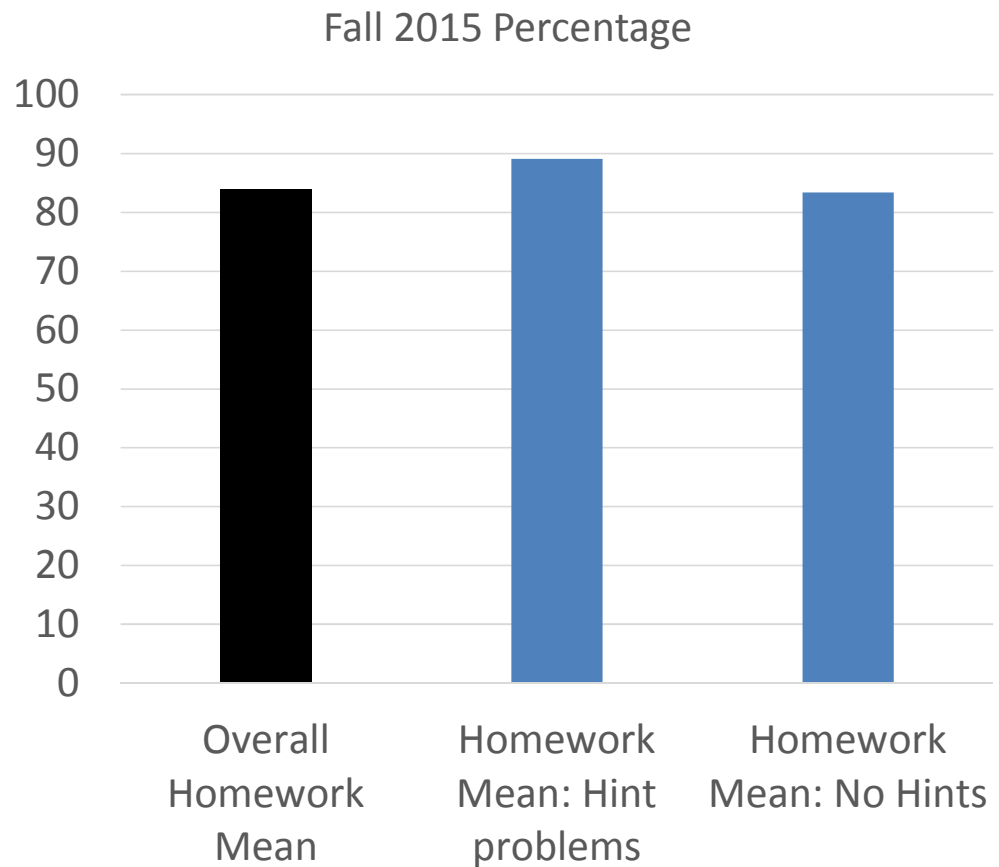
RESULTS:

- 87% of hint users found hints to be at least occasionally helpful.
- Interviews indicate that hint users are please with the hints but also recognize that these hints are not what they get from other online homework.



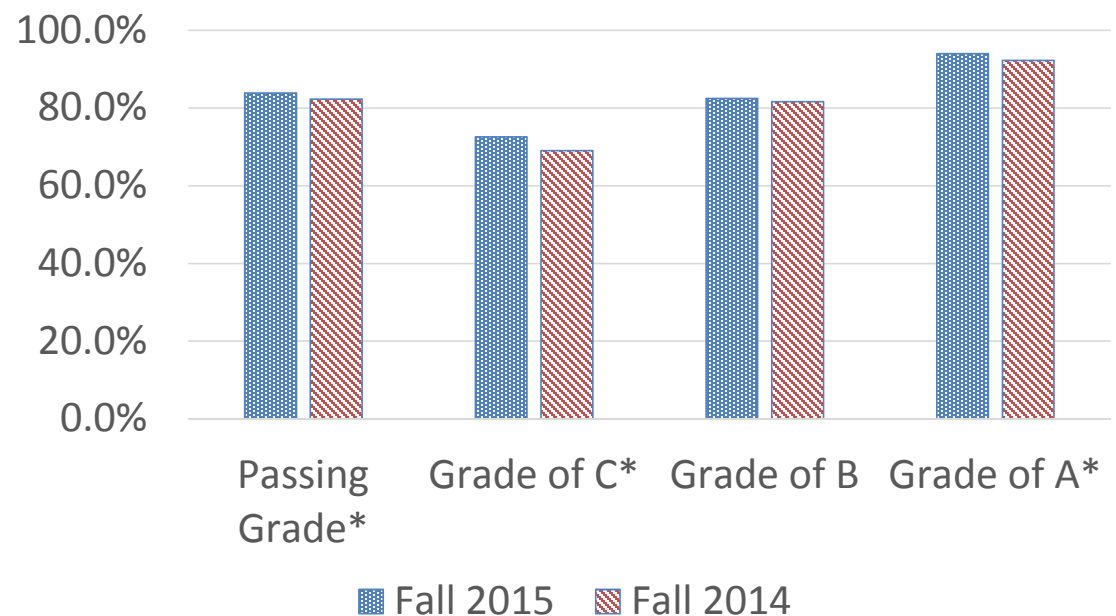
WEBWORK GRADES

- Students got more points on average on homework problems that included hints.



WEBWORK GRADES

- Students in 2015 had higher overall grades, and higher homework grades.



*indicates statistically significant differences



FUTURE RESEARCH

- Extend hints to other courses
- Create video hints
- Continue to revise and improve hints based on student feedback
- Look at individual homework problems compared with other course components.



FINAL THOUGHT

- The 2015 Kelly Fund Call for Proposals encouraged the integration of “online with traditional face-to-face classroom activities”.
- Using the Kelly-Fund we have dug into the WeBWork code and developed many new problems. This has allowed our GTA’s to focus more on student interactions and less on grading and answering homework questions.
- Our plan is to expand the use of WeBWork.



Thank you



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- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall: Englewood Cliffs, NJ.
- Hauk, S., & Segalla, A. (2005). Student perceptions of the web-based homework program WeBWork in moderate enrollment college algebra classes. *Journal of Computers in Mathematics and Science Teaching*, 24(3), 229-253.